

Development of BLE Sensor Beacon Scanner

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Abstract

Since the introduction of iBeacon by apple in 2013 there are many bluetooth low energy BLE beacons available from other manufacturers. The functionality of the beacon is extended to include sensors. The advantage of BLE sensor beacon is it has long battery life. The sensor need to upload its data to the Internet. This paper describes the development of BLE scanner using low cost processor module the ESP32, and using the Arduino IDE for software development. The uploaded data is displayed on a dashboard Grafana.

Keywords; iBeacon, BLE, bluetooth, Grafana

I. INTRODUCTION

Beacons are small wireless transmitter that is able to send signals to smartphones. The wireless technology uses by the beacon is Bluetooth low energy. The earliest beacon product is iBeacon introduced by Apple in 2013 [1]. Since then there are other beacon produce by other manufacturers such as Texas Instruments [2].

Beacons are normally use as location device. A typical usage where it gives the location of a product shelf in a supermarket through the smartphone. The beacon consumes very low current. It's typical for a beacon to have a battery life of two years or more.

The beacon functionality has now been extended. There are beacons that has sensors attached to it. Sensor beacon has the advantage of being small and consume low power. It can easily be placed in location that has difficult accessibility.

If the sensors can only be access by smartphones, the usability of the sensors is rather limited. Ideally the data acquired by the sensor beacon is capable to be uploaded to the Internet. In order to upload the sensor beacon data to the Internet some kind of scanner device is needed. An easy way to connect the scanner device to the Internet router is by WiFi.

The scanner device bridges two wireless system, BLE to WiFi.

The beacon operation is simple as it continuously transmits its identifier which is a unique device address plus the manufacturer data through the BLE advertisement packet. The advertisement packet receives by the smartphone and extracts the device address and manufacturer data to be used by the relevant apps. In sensor application the sensor data is inserted in the advertisement packet as part of the manufacturer data. The apps retrieve the sensor data by extracting the manufacturer data. The number of bytes allocated to the sensor data is limited to 32 bytes.

The scanner device hardware need to have both BLE and WiFi capability. The ESP32 module is selected as it has both BLE and WiFi. The scanner is realized by an appropriate software running on the ESP32. No additional hardware is needed.

The scanner uploaded the sensor temperature and humidity data to a virtual private server VPS running the influxdb database and Grafana dashboard server. Grafana dashboard is able to display historical data from the sensors on a graph. Grafana can also send alert whenever the received sensor data exceeded threshold that has been set.

The data is uploaded to the grafana software and influxdb database server using udp protocol.

II. METHODOLOGY

This section discussed and explain the components used to develop this project.

A. ESP32 processor module

ESP32 as shown in Figure 1 is a low cost low power system on a chip SOC microcontroller with integrated wifi and dual mode bluetooth [3]. The ESP32 uses a [Tensilica Xtensa LX6](#) microprocessor running at 160MHz or 240 MHz with 520Kbytes static ram. ESP-IDF is the programming environment provided by Espressif for programming the ESP32. An alternative programming environment is the Arduino IDE. To enable the Arduino IDE to be used for programming ESP32 additional board manager url need to be installed. The Arduino IDE has an extensive library for BLE, WiFi and HTTP protocol.



Figure 1: ESP32 module

B. Scanner Software Architecture

The temperature and humidity sensor beacon need to be scanned on a periodic basis. However, the scanning rate is not necessarily fast. In a typical temperature and humidity monitoring application the scanning rate can be every one minute or more. The scanner is designed that it comes active only when it needs to scan the sensor beacon. The scanner when first power on or wake up from sleep will activated the BLE hardware and listen for the BLE advertisement packet. It retrieves the advertisement packet and parse for the sensor beacon address and data. There can be many advertisement packets that

are received by the scanner. The advertisement packets apart from the sensor beacon can come from other BLE device such a fitness tracker.

The Arduino software for ESP32 provides library ESP32 BLE Arduino to access the BLE hardware. The library enables a callback object to be declared.

```
class MyAdvertisedDeviceCallbacks: public
BLEAdvertisedDeviceCallbacks {
void onResult(BLEAdvertisedDevice advertisedDevice) {
Serial.printf("Advertised Device: %s \n",
advertisedDevice.toString().c_str());
char data[300],data0[300];
int i;
sprintf(data,"%s",advertisedDevice.toString().c_str());
l=strlen(data);
Serial.printf("%s\n",data);
.....
.....
```

When an advertisement packet is received the packet is copied into an array data. Below is a print out of the advertisement packet received which is obtained in a single scan.

```
Advertised Device: Name: , Address: 0a:6c:49:78:46:4c, manufacturer data:
060001092002abfb507c0f59ebc307c536157521ec703dd10094bfc3a
Advertised Device: Name: Amazfit Pace-9B88, Address:
58:80:3c:b3:b6:0d, manufacturer data: 570100d8803c0d9b88,
serviceUUID: 00001818-0000-1000-8000-00805f9b34fb
Advertised Device: Name: , Address: fc:dd:88:1c:62:7d, manufacturer data:
990403651a01c27b001cffe403e80b8f00000000
Advertised Device: Name: , Address: da:4a:ed:5f:2d:31, manufacturer data:
990403631957c2850038fff804100ba100000000
```

The advertisement packet consist of device name, device MAC address and manufacturer data. Device name may not always be available. The sensor data if it's inserted is in the manufacture data. Since the advertisement packets can come from various BLE device, not all carry the same information. The right device need to be identified. In this project the sensor beacon that is use is from Ruuvi [4] as shown in Figure 2.



Figure 2 : Ruuvi Sensor Beacon

The first three bytes of the manufacturers data which is 990403 is use to identify the beacon. The next byte is the humidity data and the next two bytes is temperature.

ESP32 Arduino provides WiFi library. The WiFi access point SSID and password is hardcoded in the software.

```
// WiFi network name and password:
const char * networkName = ".....";
const char * networkPswd = ".....";
```

The data to be uploaded to the server uses udp protocol. The server udp address and port need to be specified.

```
//IP address to send UDP data to:
// either use the ip address of the server or

// a network broadcast address
const char * udpAddress = "139.99.105.138";
const int udpPort = 8888;

//The udp library class
WiFiUDP udp;

//Connecting to wifi
```

After WiFi connection is established data can then be send as udp packets.

```
udp.beginPacket(udpAddress,udpPort);
udp.printf("humidity1 value=%2.1f",h1);
udp.endPacket();
```

The software runs until it is able to upload the data and then it goes to sleep.

```
esp_sleep_enable_timer_wakeup(TIME_TO_SLEEP *
uS_TO_S_FACTOR);
Serial.println("Setup ESP32 to sleep for every " +
String(TIME_TO_SLEEP) +
" Seconds");
```

III. RESULTS AND DISCUSSION

Grafana is an open platform for analytics and monitoring [5]. The Grafana server software is hosted on a VPS (virtual private server). The Grafana server can also be cloud based which is

provided by Grafana Lab. The Grafana server software can be downloaded from Grafana Lab website and must first be installed on the VPS. Grafana server require a data source. There are many types of datasource that can be used by Grafana. One type is the influxdb database. Whenever the data is uploaded by the scanner software in the previous section, data is actually stored on influxdb database.

Data stored on influxdb can be queried through command line.

```
> select * from temperature2 limit 5
name: temperature2
time                value
-----
1562567043941421297 25
1562567448810566405 25
1562567669334067503 25
1562567832870888909 25
```

The Grafana server retrieves the data from the influxdb database and display it on a dashboard. The dashboard uses the concept of panels as the basic visualisation building block. There are five panel types: graph,singlestat,dashlist, table and text.

Figure 3 shows the is graph panel for the temperature obtained from the sensor beacon.

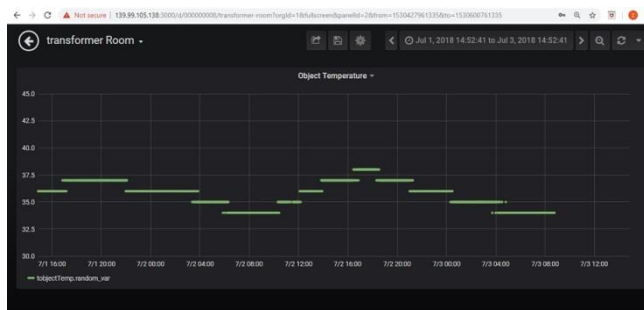


Figure 3 : Graph Panel for Temperature

IV. CONCLUSION

A bluetooth low energy scanner describes in this paper is implemented on a single hardware module. This is able to be realised with the on board WiFi and BLE hardware on the module and a simple software. The software is simple with the

availability of libraries with the Arduino IDE for the ESP32 module.

The scanner currently works for sensor beacons from a single manufacturer Ruuvi. It can be extended so that it recognises beacon from other manufacturers and their functionality.

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